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Indian Standard

CODE OF PRACTICE FOR SELECTION, INSTALLATION AND MAINTENANCE OF SWITCHGEAR AND CONTROLGEAR

PART III INSTALLATION

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Gr 7 *September* 1982

Indian Standard

CODE OF PRACTICE FOR SELECTION, INSTALLATION AND MAINTENANCE OF SWITCHGEAR AND CONTROLGEAR

PART III INSTALLATION

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Indian Standard

CODE OF PRACTICE FOR SELECTION, INSTALLATION AND MAINTENANCE OF SWITCHGEAR AND CONTROLGEAR

PART III INSTALLATION

0. FOREWORD

0.1 This Indian Standard (Part III) was adopted by the Indian Standards Institution on 19 January 1982, after the draft finalized by the Code of Practice for Power Installation and Maintenance Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 The object of this standard (Part III) is to provide detailed guidelines for the installation of switchgear and controlgear equipment and the associated auxiliaries.

0.3 It has been generally felt that the requirements of switchgears of different voltage ratings can be conveniently covered in a single section. Keeping this in view, the Indian Standard IS : 3072-1975* was brought out to cover equipment for indoor and outdoor use. Equipment so covered included circuit-breakers, isolators and other switches operating on ac or dc. Separate Indian Standards have also been formulated as follows, for detailed codes of practices for fuses, ac induction motor starters, high voltage ac circuit-breakers and other switches:

IS : 3106-1966 Code of practice for selection, installation and maintenance of fuses (voltage not exceeding 650 volts),

IS : 3914-1967 Code of practice for selection of ac induction motor starters (voltage not exceeding 1 000 volts),

IS : 5124-1969 Code of practice for installation and maintenance of ac induction motor starters (voltage not exceeding 1 000 V),

IS : 5987-1970 Code of practice for selection of switches (voltage not exceeding 1 000 V), and

IS : 7987-1976 Guide for selection of high voltage ac circuit-breakers.

0.4 This Indian Standard is being brought out with a view to update the contents of these standards and to present in a cogent fashion, the codes of practices for the various types of switchgear and controlgear used in electric power system, filling up the gaps between these specifications, utilizing the latest in concepts introduced in the product specifications.

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*Code of practice for installation and maintenance of switchgear (*first revision*).

0.5 This standard presents the subject product-wise, bringing out the relevant good practices recommended for LT and HT applications separately. The standard is being brought out in four parts namely:

Part I General
Part II Selection
Part III Installation
Part IV Maintenance

All these parts shall be read in conjunction with each other.

0.6 In the preparation of this standard, considerable assistance has been derived from the information contained in the Indian Standards listed in **0.3**. On publication of this standard (Parts I to IV), the Indian Standards in **0.3** would be withdrawn.

0.7 During the drafting of the various parts of this standard, the expert Panel, responsible for the same, had kept in view the fact that the standard could at least give guidance on the bulk of the equipment used in the country and should be understood in the manner that aspects relating to selection, installation or maintenance of EHV equipment as well as those intended for very special use would have to be supplemented with additional data, not attempted by the present series.

0.8 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part III) covers guidelines for the installation of switchgear and controlgear, of all types, intended for outdoor and indoor use.

1.2 The requirements provided here shall be read in conjunction with those of Part I of this standard.

SECTION I GENERAL

2. GENERAL GUIDELINES FOR INSTALLATION

2.1 Installation Design and Practice

2.1.0 The construction of all apparatus and conductors, and their installation shall be done in such a manner that ease of operation and maximum safety to operational and maintenance personnel is assured.

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*Rules for rounding off numerical values (*revised*).

The indoor equipment should have suitable enclosures with mechanical strength and the degree of protection against the ingress of solids and liquids appropriate to the surrounding atmosphere (*see* IS : 2147-1962*).

In the case of outdoor switchgear, where safety clearances are not adequate, it is necessary to have security fencing against contact to prevent unauthorized access.

It is also desirable that the switchgear equipment used are of few makes so that maintenance of spare is less cumbersome.

2.1.1 *Arrangement*

2.1.1.1 The following are the general arrangements of switchgear:

a) Single bus-bar arrangement,
b) Ring bus-bar arrangement,
c) Double bus-bar arrangement,
d) Mesh bus arrangement,
e) Transverse bus arrangement, and
f) Main and transfer bus arrangement.

2.1.1.2 The arrangement of switchgear in sub-stations is, to a great extent, dependent on the degree of reliability, consistent with economy. It is recommended that the following general principles should be borne in mind:

a) Individual circuits should be so designed that risks of failure are minimum;
b) The layout should be so arranged that sections may be isolated with a minimum interference with service;
c) Easy access for operation, maintenance and inspection should be provided;
d) Provisions should be made for dealing with fire;
e) Sufficient precautionary measures should be taken to provide safeguards to operating personnel from coming into contact with live parts;
f) Clearance between live conductors and between live conductors and earth shall be related to the basic insulation level of the substations concerned.
g) The arrangements should have enough flexibility for expansion. In the case of standby power, provision should be made to segregate the essential from non-essential loads.

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*Degrees of protection provided by enclosures for low voltage switchgear and controlgear.

2.1.2 *Site* — The site should have suitable approach as the equipment for high voltages are bulky and may be of considerable weight. Due attention should be given to proximity to inhabited areas when considering air blast switchgear which can be very noisy. The equipment shall be so placed as to give adequate access for operation and maintenance work; in this respect manufacturers generally provide minimum requirements which should be followed. Adequate space should be provided for auxiliaries, piping, etc. While erecting, due attention shall be given to ensure that the switchgear is at sufficient height to prevent damage from any flooding during rains.

2.1.3 *Rating of Equipment* — The rating of the switchgear required for any particular installation shall normally be influenced by the following:

a) Prospective short-circuit current (if necessary, taking into consideration future extension) so as to find out the breaking capacity and thermal and dynamic short-circuit strength of the equipment;

b) Supply voltage;

c) Nominal current-carrying capacity, taking into consideration the continuous dynamic as well as short-time rating of the connected equipment;

d) The ambient temperature, humidity conditions and the elevation above mean sea level;

e) Making capacity; and

f) Power factor of the fault current to be interrupted.

Guidance on selection of equipment is covered in Part II of this standard.

2.1.4 *Extensions or Alterations* — Due consideration should be given in designing the original installation for any possible future extensions or alterations, particularly to take care of large short-circuit currents which may result in the existing installation proving inadequate for the new duty imposed upon it.

2.1.5 *Electrical Protection of Circuits and Apparatus* — All apparatus and associated cable work should be protected against electrical faults in the circuits by a suitable device. The main function of such protective device is to localize and limit the extent of damage to the apparatus protected. The various protective devices should be so selected and adjusted as to provide discriminate operation.

2.1.6 *Main Connections*

2.1.6.1 *General* — Depending on the type of application required, the main connections to the switchgear may be cables, bus-bar or conduit runs. The interconnection between switchgear units may usually be bus-bar runs of one form or the other.

2.1.6.2 *Bus-Bars* — Bus-bar runs should be designed taking into account operating short circuit current particularly the thermal expansion resulting out of flow of heavy currents; supports along their length, and spacing for laminated runs should be based on electromagnetic forces which prevail during short-circuit conditions. In case of outdoor switchgear, effect of atmospheric pollution should also be considered while designing the bus-bar runs. Ventilation conditions should be considered for indoor switchgear, while designing the bus-bar runs.

2.1.6.3 *Conduit* — For smaller sizes of switchgear as well as for auxiliary circuit wiring, connection may be made by cables in conduits.

2.1.6.4 *Cables* — All main cables should be chosen taking into account site conditions which affect operating current, and also the possible short-circuit currents available from the equipment to which they are connected.

While planning cable runs, due consideration should be given to interference in the event of fire.

The cables shall be laid in accordance with good practice (*see* IS : 732-1963*, IS : 1255-1967† and IS : 2274-1963‡).

2.1.7 *Ancillary Equipment* — The ancillary equipment, such as batteries and control boards shall be properly designed for use with the switchgear with which they will be associated.

2.1.8 *Precaution Against Risk of Fire*

2.1.8.1 If switchgear is installed in chambers situated below blocks of building which are ordinarily frequented by many people or in places where the fire risk is considerable, the following precautions are recommended:

a) The structure and, in particular, any partition walls or partitions and doors should be of such construction as to be capable of resisting the effects of fire for a considerable period and for resisting the effects of an explosion. The adequate arrangement for draining the oil should also be made.

b) Independent ventilation of the chamber should be provided and any trunking which is in communication with other parts of the building be excluded therefrom. Access doors to the chambers where the equipment is installed should be provided. Natural ventilation shall be provided as far as possible.

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*Code of practice for electrical wiring installations (system voltage not exceeding 650 volts) (*under revision*).

†Code of practice for installation and maintenance of paper insulated power cables (up to and including 33 kV) (*first revision*).

‡Code of practice for electrical wiring installations (system voltage exceeding 650 volts) (*under revision*).

c) Suitable fire extinguishers, such as CO_2 type or dry chemical type, shall be placed in an easily accessible place, adjacent to the fire risk area but not in it.

d) In order to reduce fire risk and preserve accessibility, articles not strictly necessary for maintenance purposes should be rigorously excluded from switchrooms and sub-stations.

NOTE — The importance of the appropriate fire extinguisher to be used for various types of electrical fires cannot be over emphasized; for instance spraying of water on live parts of electrical apparatus on fire would charge the pipe work and may endanger the lives of fire fighting staff.

2.1.8.2 *Switchgear using oil* — The more important installations are arranged to operate with a form of emulsifying spray automatically operated by sensing devices suitably located.

2.1.8.3 Regarding fire safety of the electrical installations reference may be made to IS : 1646-1961*.

2.1.9 *Clearances* — The clearances recommended between phase to phase and phase to earth, and sectional clearances for outdoor switchgear are given in Table 1. These are the minimum clearances (between exposed conductors of the phases or live metal parts or live metal parts and earth) which shall be maintained in all conditions. Due allowance shall have to be given to take care of conductor movements and sagging in worst conditions. These values are based upon the impulse voltage withstand levels specified for the equipment and may be used in majority of the cases. If the clearances based on the transient overvoltage on the system may be found higher than the values given in the table, the higher values may then be used in those cases.

2.2 Inspection Storage and Handling

2.2.1 *Inspection* — Switchgear is often dismantled before despatching, the parts being packed separately. All items of equipment should, therefore, be carefully inspected as soon as possible upon arrival at site to ascertain whether they have been damaged in transit or whether any items are missing. Particular attention should be paid to bushings, meters and relays which are the items most liable to damage.

NOTE — Advice tendered by manufacturers for unpacking and lifting should be followed to prevent damage.

2.2.1.1 Packing cases should not be unpacked in a damp place, nor out of doors if it is raining.

2.2.2 *Storage* — Switchgear and associated equipment which are not required for immediate use should be stored in a clean, dry and airy place. The site chosen for such storage should be cool and free from dust and

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*Code of practice for fire safety of buildings (general) : Electrical installations.

TABLE 1 MINIMUM ELECTRICAL CLEARANCE FOR OUTDOOR SWITCHGEAR

(*Clause* 2.1.9)

VOLTAGE RATING (HIGHEST SYSTEM VOLTAGE)	IMPULSE WITHSTAND LEVEL*	MINIMUM CLEARANCE TO EARTH†	MINIMUM CLEARANCE BETWEEN PHASES	MINIMUM CLEARANCE FROM ANY POINT WHERE THE MAN MAY BE REQUIRED TO STAND TO THE NEAREST UNSCREENED CONDUCTOR IN AIR (SECTIONAL CLEARANCE)
(1)	(2)	(3)	(4)	(5)
kV (rms)	kV (peak)	mm	mm	mm
12	60 (List I)	90	90	2 600
	75 (List II)	120	120	2 600
36	145 (List I)	—	270	2 750
	170 (List II)	320	320	3 000
72·5	325	630	630	3 500
123	450	900	900	3 500
	550	1 100	1 100	4 000
145	450	900	900	3 500
	550	1 100	1 100	4 000
	650	1 300	1 300	4 000
245	650	1 300	1 300	4 000
	750	1 500	1 500	—
	850	1 600	1 700	4 500
	950	1 900	1 900	4 500
	1 050	2 400	2 100	5 000

*The impulse withstand levels are as given in IS : 2165-1977 Insulation coordination (*second revision*). For guidance regarding choice between List I and List II (as in col 2) for rated voltages 12 kV and 36 kV and between levels against higher rated voltages, *see* IS : 2165-1977.

†The values of minimum clearance to earth are based on Table 6A of IS : 3716-1978 Application guide for insulation coordination.

corrosive gases. When oil circuit-breakers are not commissioned immediately on arrival at site, it is most important that the breakers and any other chambers normally containing oil in service should be filled with oil.

Packing materials such as wood, wool or straw packed around insulation other than porcelain, should be removed as they may absorb moisture.

If the material is left stored in packing cases, the latter should be raised clear off the floor on battens, so that air may circulate freely beneath it. If the packaging cases are not designed for prolonged storage at site, then the user shall make arrangements for unpacking immediately on arrival of the consignment at the destination.

Rats and other vermin and termite are a source of considerable trouble, as they damage items such as insulation; special precautions are, therefore, necessary. It is recommended that periodic inspection be carried out for signs of damage resulting out of attacks by vermin.

The above recommendations also apply to any spares which may be kept in stock.

All parts which contain compound should be unpacked upon receipt, and placed in a position similar to that which they shall occupy in service, so that the compound has the maximum time to regain its normal position.

2.2.3 *Handling* — All items of switchgear shall be carefully handled to avoid damage or breakage; many parts are made of insulating material which are likely to suffer easily, if not handled carefully.

Slinging shall be carried out only at the points provided for it, and not by bushings and the like.

2.3 Installation Work

2.3.0 *General* — A set of drawings should be drawn up by the installation engineer or contractor, indicating the layout of the installation and the wiring system. In case of outdoor equipment these will include plan and sectional elevations of the switchyard showing the arrangement of bus-bars, location of different equipment of switchgear, clearances; arrangement of trenches, drainage and other facilities. The approval of the user shall be obtained before the work is commenced. Manufacturer's erection instructions, if provided, shall always be followed.

2.3.1 It would be better to draw up an erection summary on the following lines and check the following points:

a) Foundations and other civil engineering works;

b) Assembly of circuit-breaker and mechanism;

c) Alignment of the complete unit;

d) Grouting of foundations;

e) Fitting of loose instruments;

f) Adjustment of circuit-breaker, contact travel, etc;

g) Connections of interlocks, if any;

h) Oil filling in case of oil circuit-breakers;

j) Main circuit connections;
k) Earth connections;
m) Small wiring;
n) Checking of arc control devices;
p) General inspection;
q) Connection of multicore circuits;
r) Degree of protection provided by type of enclosure;
s) Removal of blockings of moving parts provided for transportation; and
t) Testing and commissioning.

2.3.2 *Location* — Indoor switchgears shall be installed in an adequately ventilated location free from damp, corrosive gases, dust and inflammable vapours, except when the equipment has been so designed as to withstand such conditions.

2.3.2.1 Manufacturers, while supplying their equipment shall specify the minimum requirements, which should be followed. However, the equipment should be so placed as to give adequate access for operation and maintenance work.

2.3.2.2 Storage batteries should be placed in a separate room having chemically resistant floor and walls skirted with chemically resistant tiles up to a suitable height. The window panes of this room should be painted in such a way as to avoid the sun's rays entering this room. Care should be exercised in handling during erection and special precautions shall be taken to avoid acid burns and provide adequate ventilation arrangements, such as ventilating fans. All equipment and hardwares used in battery room should be protected against corrosion due to acid fumes.

2.3.3 *Preliminaries* — All civil work in the buildings, in which the equipment is to be installed, shall be in an advanced state of completion when the installation work of the switchgear is started. Particularly in case of indoor switchgear, arrangements should be made and precaution shall be taken to protect the equipment against rain and ingress of dust.

Floor space and the cable trenches shall be cleared of all construction material, scaffolding, etc.

Interior decorations, paint work, etc, shall not be undertaken during erection. This shall await completion of erection if not already finished and equipment can then be covered by dust-proof sheets.

2.3.4 *Foundations* — The foundations should be designed to carry not only the dead weight of the units, but also the additional impact load imposed when a switch opens under short-circuit conditions. The impact load may be as much as twice the dead weight, and manufacturer's recommendations in this respect shall be followed. Wherever applicable, forces and likely movements due to earthquake shall be taken into consideration.

2.3.5 *Levelling and Grouting* — The assembly of units of switchgear, particularly the larger sizes of metal-clad gear, is a job which requires precision workmanship. Great care shall, therefore, be taken to ensure that the equipment has been installed correctly and levelled properly before the holding down bolts are grouted in, thereby ensuring correct operation of isolation mechanisms and joining together the bus-bars of the various units.

2.3.5.1 For metal-clad draw out type gear, it is essential that the floor is level in front of the equipment for some distance to facilitate handling of the moving portion.

2.3.6 *Connections*

2.3.6.1 *Bus-bars* — When the main bus-bars of units of switchgear are connected together to form a switchboard, it should be ensured that the connections between units are properly made and are tight. When two or more equipment are to be connected together to form a switchboard, they shall be aligned and bus-bars shall be connected in such a way as to provide adequate clearance between phases, and phase and neutral (if neutral bus-bar is to be provided).

When making connections to terminals of switchgear, care shall be taken to avoid undue strain on insulators.

For rigid bus-bars, due regard for expansion shall be considered and for all connections to parts incorporating porcelain, expansion type connectors at one end of the bus-bar shall be provided.

2.3.6.2 *Main connections* — The connection to the switchgear should be done carefully making sure that they are tight, and are of the correct phase sequence.

Where bus-bars are used, joints shall be either tinned, silver plated, or, if bare, should have a small coating of any conducting grease to ensure good contact.

NOTE—Bimetallic connectors may be required when connections made between two dissimilar metals.

i) *Flexible connections* — Correct tensioning of flexible type connections, that is, stranded conductor, shall be carried out.

ii) *Rigid connections* — To ensure neat looking set of bus-bars, it is usual to prebend such bars in the opposite direction to the sag, so that when in position the actual disposition is horizontal.

2.3.6.3 *Auxiliary connections* — On many types of switchgear there will be auxiliary circuits, such as tripping, closing, indicating and metering. These may be connected to sources of supply or control panels in accordance with approved connection drawings.

2.3.6.4 *Meter and relay connections* — It is absolutely essential that secondary connections from current transformers shall be made to form a closed circuit as dangerous voltages may develop under open-circuit conditions and may puncture the insulation of the current transformer.

Relays and meters shall be placed and connected up in accordance with the drawing supplied by the manufacturer.

During connections, checks should be made to ensure that the ratings of current transformers and ratings of meters and relays should match. If the ratios of current transformers and meters, relays, etc, do not match, the multiplying factor shall be stencilled on the meter and adjustment of setting made in the case of instrument transformer in accordance with the approved drawing.

The connections should be by means of short wires neatly clipped and supported. Long and loose wires should not be used as they may foul with main connections.

2.3.7 *Oil-Tight Joints* — When it is necessary to make oil-tight joints, the joint faces, gaskets and the operator's hands should be scrupulously clean, before and during assembly. Joining material should be applied as directed and the bolts tightened up evenly, not more than half a turn at a time, and finally pulled up as tight as possible.

2.3.7.1 *Air-tight Joints* — For air blast switchgear or switchgear having pneumatically operated mechanisms, due care and attention to joints in piping with air at pressure should be given. Tests should be made for air leaks after installation to ensure correctness of such joints. This is best done by using a thin soap solution.

2.3.8 *Ancillary Apparatus*

2.3.8.1 *Power supplies*

a) *Pneumatic* — Equipment for pneumatic-power closing of circuit-breakers shall be in the form of special compressors. These will require careful erection to ensure sufficient air-tightness in the piping system which may work at high pressures. Cleanliness is essential on pneumatic systems. The air piping shall be installed with a slight incline to enable draining away any moisture contained in the air.

b) *Pneumo-hydraulic* — Under consideration.

c) *Electric* — Electric solenoid mechanisms require sources of current and could operate on ac or dc. For mechanisms requiring dc source, it is usual to provide a rectifier or storage battery.

The distribution network fed by the batteries should be planned in such a manner that the fault on any feeder does not completely discharge the battery or otherwise jeopardise the operation of the protection system. This may require the segregation of the supply to essential and standby equipment. Alternatively, in order to avoid undue drain of the storage battery, it may be preferable to provide a separate rectifier for the closing of the solenoid mechanism so that normally ac supply is used for the operation.

d) *Spring closing mechanisms* — These are operated from a spring which may be charged by hand or motor, the energy to close is released by operation of a latch.

2.3.8.2 *Tripping circuits*

a) Automatic tripping of the switchgear, if not of the series type, will require a battery or a power pack for dc supply.

NOTE — Alternatively, it may also be operated on a current transformer operated tripping mechanism.

b) Power packs intended for the purposes of automatic tripping shall retain sufficient charge to trip the breakers in case of ac failure. In the design of power pack systems, due attention shall be given to the back-up relay timing. It may also be necessary to use more than one power pack for a single switchgear where there are many relays requiring auxiliary power supply, or if power is needed to be provided for other functional requirements. The condition of the power pack shall also be periodically monitored.

2.3.8.3 *Control panels* — Large installations may be provided with separate control panels located remote from the switchroom. Requirements concerning foundations, grouping, lining and levelling for the main switchgear also apply to these equipment.

2.3.9 *Earthing* — All equipment shall be solidly and efficiently earthed; the earth connection to switchboards being rated for the expected short-circuit level at that point (*see also* IS : 3043-1966*).

2.3.10 *Drying Out of Insulation*

2.3.10.1 *General* — The main part of a switchgear, regardless of voltage, is its insulation, and this insulation may take many forms, such as porcelain, oil and compound. Many types of insulating materials used on switchgear are likely to absorb moisture during storage. Care shall, therefore, be taken to ensure that all equipment has had its insulation thoroughly dried before final commissioning and energizing.

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*Code of practice for earthing.

Porcelain does not absorb moisture, but it should be thoroughly cleaned.

Bonded resin laminates are liable to absorb moisture and during erection all items of switchgear having such insulation should have lamps of sufficient wattage placed at various points, so that the heat flow from these lamps will dry out the insulation.

Care shall, however, be taken to protect the insulation from direct local heat, as it may result in blistering of the insulation.

Oil should be thoroughly clean and dry before being filled into any part of switchgear (*see* IS : 1866-1978*).

Windings of voltage and current transformers may also require drying out. The manufacturer should be consulted in case the switchgear is completely wet.

2.3.10.2 *Drying out* — If the measured insulation resistance of the switchgear is less than 1 megohm for rated voltages of 1 000 V, 100 megohms for rated voltages above 1 000 V and up to and including 33 kV, and 1 000 megohms for rated voltages above 33 kV, it should be first dried out before it is switched on. Due care and attention shall be paid when measuring insulation of resistance with particular reference to climatic conditions, cleanliness of insulation, etc.

a) *Principles of drying out* — Whatever method is employed for drying out, the general principle is to apply heat continuously for a considerable time so as to drive out any moisture which may have become entrapped. During drying out period it is recommended to take measurements of the insulation resistance periodically. It will generally be found that at the beginning of the drying out, moisture is redistributed. After some time the insulation resistance value reaches a minimum value and then stabilizes at this value for some time, after which it begins to increase until it reaches its maximum value. This maximum value is generally much greater than minimum values specified in (b). When the maximum value of the insulation resistance has been reached, it is safe to put the switchgear into service.

b) The minimum value of insulation resistance should be 1 megohm for switchgears of voltage ratings of 1 000 V, 100 megohms for voltage ratings above 1 000 V and up to and including 33 kV and

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*Code of practice for maintenance and supervision of insulating oil in service (*first revision*).

1 000 megohms for voltage ratings above 33 kV. A 1 kV megger shall be used for ratings up to 1 000 V and for higher ratings motorized meggers of 2·5 kV and above shall be used.

NOTE — The relationship between temperature and insulation resistance values in switchgear equipment has not yet been accurately established owing to the several other influences. This is being studied.

2.3.11 *Mechanical Adjustments* — Mechanism circuit-breakers should be checked against the manufacturer's drawing to ensure that the works settings have not been disturbed during transit.

2.3.11.1 The large units may require site adjustment to manufacturers' drawings. Special care is required for units comprising 3 single-phase units to ensure the correct and simultaneous operation of all three phases.

2.3.11.2 *Isolators* — Most outdoor installations use some form of air-break isolators operated usually by an arrangement of linkages together from one point. Correct setting is essential to ensure that such mechanisms are freely moved but go over toggle and lock-in-position when fully closed. Failure to ensure this may result in a switch opening on the short-circuit conditions with disastrous results.

2.3.12 *Filling of Oil* — Only dry and clean oil should be used. Before filling with oil, the oil circuit-breaker tank should be thoroughly cleaned and extraneous material, such as packing pieces, if existing, should be removed. The fixed and moving contacts shall be checked and cleaned. In oil filling it shall be ensured that no dust or moisture enters the oil and that it is at least as warm as the surrounding air. The oil should be filled with either a centrifuging machine or filter press type machine using flexible hoses. Rubber hoses shall not be used since the sulphur in the rubber would be dissolved in oil causing its dielectric strength to be lowered and also the dissolved sulphur would attack copper in the fixed and moving contacts.

2.3.13 Where there is a likelihood of condensation, heaters may be provided.

3. TESTING AND COMMISSIONING OF SWITCHGEAR

3.1 General — The equipment, when erected, should be thoroughly cleaned and check should be made to ensure that:

a) all nuts, bolts and clamps are tight;

b) all components containing oil, other liquid or compound are filled to the correct level;

c) all moving parts, where required, are lubricated;

d) breaker operates mechanically;

e) all wiring is in accordance with diagram;

f) earth connections are connected to main earth bar;

g) no tools or loose materials are left in and around the switchgear; and

h) arc chutes are fitted in position, wherever applicable.

3.2 Oil — All components containing oil as an insulating medium should have samples taken from each item preferably from the bottom of the tank, and breakdown values of the oil tested. For new oil, the test should be made at 40 kV for one minute. Reference should be made to IS : 1866-1978* and IS : 335-1972†. In the case of other fluids, test as specified in the relevant specification should be performed.

3.3 Air — On any unit using air, the system should be thoroughly cleaned out and check made to ensure that no moisture is present. Correct functioning of moisture traps is essential.

3.4 Insulating Tests

3.4.1 *Insulation of Main Circuit* — The insulation of the main circuit is associated with the main connections. The insulation resistance to earth of each phase and between phases should be measured in turn.

It is expected that the readings of insulation resistance in excess of the minimum values specified in **2.3.10.2**(b) should be obtained. Any reading considerably lower should be suspected and investigation should be carried out to trace the source of low readings.

3.4.2 *Insulation of the Auxiliary and Control Circuit* — Insulation resistance to earth of all secondary wiring circuits should be tested using a 500 V megger. Readings obtained for a single or combination of circuits should be not less than 1 megohm.

The insulation test shall be carried out both before and after high voltage test, if performed.

3.5 High Voltage Tests

3.5.0 *General* — The application of high voltage test to switchgear after erection is not universal, but this may be called for under social contractual conditions. The tests applied will vary depending on whether the installation is a new one, an extension to existing gear, or carried out in conjunction with other equipment. It is preferable that such tests be carried out with ac though tests with dc may also be permissible.

3.5.1 *Insulation of Main Circuit* — A voltage dependent on the working voltage of the switchgear shall be applied in accordance with the values specified in the relevant Indian Standard (*see* Appendix A). The frames

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*Code of practice for maintenance and supervision of insulating oil in service (*first revision*).

†Specification for new insulating oils for transformers and switchgear (*second revision*).

and secondary windings of all current transformers and potential transformers included in the test shall be earthed. If the voltage transformer is to be included in the test, both ends of the high voltage winding shall be connected together. In a voltage transformer one end of the high voltage winding is normally earthed, and a pressure test shall not be carried out, as the insulation may be graded.

This test should be carried out on each phase in turn, with the remaining phases earthed and all units racked in position and breakers closed.

Insulation resistance test shall be carried out before as well as after the high voltage test to ensure that there has been no reduction in value. If the second reading is lower, each separate component should be tested to find out where the lower figure has occurred.

The following precautions should be observed when conducting the high voltage test:

a) During the test one terminal of the testing transformer shall be connected to earth and to the frame of the circuit-breaker;

b) The test shall be commenced at a voltage of not more than one-third of the test voltage; and

c) The voltage shall be increased from its initial value as rapidly as is consistent with its value being indicated by the measuring instrument. The full test voltage shall then be maintained for the appropriate duration as the case may be and then be reduced to its initial value and switched off.

NOTE — In addition to the General precautions above, guidance shall be taken from the relevant product specifications regarding the value of the test voltage and the duration of application. For high voltage tests at site, the manufacturers' recommendations shall be followed.

3.5.2 *Insulation of the Auxiliary and Control Circuit* — The secondary circuits associated with the equipment should be tested by looping all ends together and applying 2 000 V ac for one minute. All current transformer and voltage transformer earth connections shall be disconnected for this test, and should be replaced immediately after.

3.6 Operation Checks — All types of mechanism should be operated slowly to check that contacts are in correct alignment. On no account should a power operated mechanism be operated by power until operation by hand has proved it completely satisfactory.

Manufacturers sometimes provide special closing devices for use during commissioning and maintenance. Necessary precautions as laid down by the manufacturers shall be taken into account when these devices are used.

All switchgears with power closing and tripping should be checked for operation at maximum and minimum values of operating media, to ensure correct tripping and latching-in at these values, say for pneumatic mechanism; the maximum pressure and minimum pressure should be used, and the breaker should operate satisfactorily under any of these conditions.

DC voltages, applied to solenoids, shall be checked with current flowing, as the value obtained will depend on the state of charge of the battery.

Correct closing and tripping of the circuit-breakers by remote and local control should be checked including tripping by protective relays. These tests should be carried out both positively and negatively such that when the relay is operated, it trips only the associated equipment with everything else remaining normal, but when any of the associated control fuses are removed, the relay operation does not trip the associated equipment.

3.6.1 *Isolators* — Correct closing and opening shall be checked as well as contact alignment.

3.7 Surge Protection

3.7.1 The desirability of providing protection to the switchgear from surges of atmospheric or other origins shall be examined carefully in every case. Installations including terminations of overhead lines as well as cables, require careful study.

3.7.2 Most outdoor installations include surge protection by way of rod gaps mounted on circuit-breaker bushings, isolator stacks, etc. These may be fixed or adjustable and due attention should be given to rating as required by insulation co-ordination.

3.7.3 Lightning arresters may also be employed to protect the switchgear from surges. Reference shall be made to IS : 3070 (Part I)-1974* and IS : 4004-1978† for proper selection of the lightning arresters.

3.8 Protective Apparatus

3.8.1 *General* — Many forms of protective systems are used in conjunction with switchgear, from simple fuses to various types of protection of a complex nature.

A thorough check of protection scheme is essential before commissioning. The object of site tests is to prove that the protective scheme is operating correctly and shall operate on faults within the protected zone, but not operate on other faults.

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*Specification for lightning arresters for alternating current systems: Part I Non-linear resistor-type lightning arresters (*first revision*).

†Application guide for non-linear resistor-type lightning arresters for alternating current systems (*first revision*).

Tests should be made as simple as possible, as elaborate testing equipment is not available usually. This fact should be remembered when interpreting the obtained test results and evaluating them against any values provided by the manufacturer.

Tests on protective circuits should be so arranged that as little disturbance as possible is made with connections. Each current transformer system shall be earthed only at one point. Check may be made by removing the known earth lead and checking by megger; during this test the primary shall not be live.

In testing protective gear, distinction should be made between commissioning tests, routine and post-fault checks. It is essential to keep detailed records of commissioning tests to provide a reference for future routine checks. Greatest care should be taken when tripping the circuit-breakers by operating the relays with hand in order to avoid damage to relay mechanisms and contacts and to avoid alteration of relay settings. A record of the correct settings of all protective relays should be kept available and up-to-date, and care should be taken to restore the settings to their correct values if they are altered during tests.

If connections are disturbed or temporary connections made during the course of testing they should be made good before making the switch unit live. Attention is drawn to the dangerous voltages which may result if the secondary circuits of current transformers are opened.

3.8.2 *Removal of Dust* — It is important that the dust should be wiped from relay covers before these are removed; and it is equally important that these covers are replaced securely so as to exclude dust.

3.8.3 *Injection Testing* — Primary injection testing should be used wherever conditions permit, in preference to secondary injection.

Secondary injection testing may be used for routine checks on relays. Such checks on protective apparatus at regular intervals are more important rather than elaborate tests carried out infrequently.

3.8.4 *Induction Relays* — Induction relay discs should not be rotated by hand. If it is desired to check the tripping circuit, this may be done by rotating the discs by means of the time setting adjuster.

Tests should be made to check operating and resetting times of induction relay when work is done which is liable to alter their characteristics.

3.8.5 *Fuses* — Check should be made that all fuses in main and auxiliary circuits have been fitted, and that the ratings are appropriate to the circuit in which they are installed.

3.8.6 *Trips and Releases* — Under voltage release features should be checked at regular intervals to ensure satisfactory operation.

In the case of series trips, the freedom of the solenoid armature to move should be particularly checked. If a fluid-filled dashpot is filled, it should be checked to verify that it contains the correct quantity and quality of the fluid recommended by the manufacturer. It is most important to remove all sludge and clean the device before refilling.

3.9 Batteries — The battery should be commissioned in accordance with instructions provided by the manufacturer. Any trickle chargers associated with the equipment should be set to give a small definite continuous charge. In the case of lead-acid batteries it should be enough to hold cell voltage between 2·0 and 2·2 volts.

3.10 Pneumatic Systems — The system should be checked for leakage of air by pressure drop and, if excessive, all valves, pipe joints and connections should be checked. A soap solution applied with a brush may be used for checking leaks on pipe joints.

3.11 Switching-in — When checks mentioned above have been carried, and it is as certain as possible that equipment is in working order the equipment may be switched on to the supply. For this initial energizing, it is recommended that protective equipment be set at minimum value to ensure a rapid tripping in the event of any untoward occurrence. Inspection of voltmeters and ammeters should be carried out to ensure that they are working, and a visual inspection made of all the equipment.

Before final commissioning, necessary approval should be obtained from the appropriate authority. It is necessary to maintain record of test on the equipment. All the workmen before initially charging the equipment should be alerted for any possible mishap.

SECTION 2 SPECIFIC GUIDELINES FOR LOW VOLTAGE EQUIPMENT

4. SPECIFIC GUIDELINES FOR INSTALLATION OF EQUIPMENT FOR VOLTAGE BELOW 1 000 V

4.0 The guidelines contained in the following clauses are supplementary to those in Section 1.

4.1 Fuses

4.1.0 *General*

4.1.0.1 To ensure that the fuses offer the desired protection, the following general precautions are absolutely necessary for their use:

a) Fuse wires, cartridges or the fuse-links should be of the appropriate rating. While the characteristics of D-type and link-type fuses are more or less independent of the fluctuations in the ambient temperature, the fuse-element of rewirable fuses may have to be derated for higher ambient temperature; and

b) External sources of heat generation should be eliminated by:
   1) selecting the connecting cables of adequate size,
   2) tightening the screwed joints properly from time to time, and
   3) not installing the fuse units on top of any heat generating equipment.

4.1.0.2 For the sake of proper discrimination, it is essential to observe that:

a) due to the manufacturing tolerances, the fuses which are connected in series are as far as possible of the same manufacturer;
b) the quick acting and slow acting type of fuse-links are not mixed up, and
c) successive fuses in the system are properly graded (*see* Part II of this standard).

4.1.0.3 The fuses should be installed at a readily accessible place taking care that accidental contact to the other live parts is prevented.

4.1.1 *Rewirable Fuses*

4.1.1.1 The fuse-element is usually of tinned-copper wire which is screwed to the fuse carrier. The carrier is then inserted into the base which is provided with the fixed contacts. The fuse wire should be checked by a gauge or a micrometer. Taking a strand from a stranded conductor of an insulated cable is prohibited.

4.1.1.2 Being in contact with open atmosphere, the fuse-element tends to deteriorate even when the rated current is flowing. The rate of deterioration increases tremendously if the fuse-element is subject to repeated overloads, as are usually associated with the motor operations.

4.1.1.3 It is essential that the fuse-element is securely fitted. When a fuse of higher rating is required, sometime two or more wires are used in parallel. In such cases, they should be spaced and their rating as a fuse be reduced. For example, if there are two strands, the rating should be taken as about 0·7 to 0·8 times the total current carrying capacity.

4.1.1.4 The fuse-element may be checked before starting any motor and if any of them show signs of deterioration, all the fuses should be changed. Similarly, fuse-elements on all the phases should be replaced even when one of the elements had operated.

4.1.2 *D-Type Cartridge Fuses*

4.1.2.1 The D-type cartridge fuse unit comprises the fuse-base with fixed contacts, fuse cartridge, the adapter screw and the screw cap. The indication of the operation of the fuse cartridge is given by a pin which comes out and is visible from outside through the glass window provided in the screw cap. The fuse unit does not require any maintenance, except for the tightening of the terminals of the incoming and outgoing leads from time to time as in the case of any other equipment. The screw cap should be tightened properly and checked for tightness from time to time.

4.1.2.2 To avoid improper use, the fuses should either be installed such that they are accessible only to authorized persons, or other measures should be taken to prevent improper use (*see also* **4.1.4**). In case of D-type fuses, it is possible to provide adapter screws in the fuse-base so that a fuse cartridge of only a particular rating may be inserted.

4.1.3 *Link-Type Cartridge Fuses*

4.1.3.1 There are two types of cartridge fuse-links, namely:

a) knife-blade type contacts corresponding to Data Sheet I1 in accordance with IS : 9224 (Part II)-1979*, and

b) bolted type contacts corresponding to Data Sheet III1 in accordance with IS : 9224 (Part II)-1979*.

4.1.3.2 The knife-blade type of fuse-links are inserted directly into the fuse-base without any screwed joint. These fuse-links may, as such, be inserted and removed by a common insulated fuse puller even when the circuit is live but at no load. The bolted type of fuse-links, on the other hand, are screwed into an insulated fuse carrier with the possibility of insertion into or removal from the fuse-base. In case of direct connection of bolted type fuse-links, it should be ensured that they are isolated from the supply before removal and installation. It should, however, be noted that in either case the fuse-links should be removed only after the connected loads have been switched off.

4.1.3.3 The design of cartridge fuse-links is such that they may be overloaded any number of times up to the melting point of the fuse-element without any appreciable deterioration of the element.

4.1.4 *Precaution* — It is dangerous for the plant as well as for the operational personnel to replace the fuse-elements of cartridge fuses by a fuse wire because in such a case there is a possibility of fire and explosion. No means exist in such cases to take away the arc-heat in case of excessive short-circuits. Both D-type and link-type cartridge fuses should not be wired at site but only at the manufacturers' works, if such a facility exists.

4.1.4.1 Adequate number of spare fuses should be readily available. Fuses with damaged bodies should be replaced immediately. Reusing of

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*Low voltage fuses : Part II Supplementary requirements for fuses with high breaking capacity for industrial application.

D-type or cartridge type fuses are also not recommended by the manufacturer. This fact shall also be kept in view during replacements. It is also recommended that the ceramic bodies of blown fuses shall be destroyed.

4.2 Switches and Combination Units of Switches and Fuses

4.2.1 It must be ensured that the equipment is stalled as per the instructions of the manufacturer. For instance, certain equipment are suitable for mounting in a vertical position only.

4.2.2 The equipment should be installed such that operating handle is easily accessible and operable in event of emergency.

4.2.3 Under no circumstances equipment intended to be used with high rupturing capacity cartridge fuse-links should be used with either rewirable fuses or reconditioned HRC fuse-links.

4.2.4 It must be ensured that the terminals available in the equipment are adequate for the sizes of incoming and outgoing cables (generally PVC insulated cables with aluminium conductors). Otherwise, the terminals have to be modified (for example, by adding extended connections) so as to to receive the respective cables.

4.2.5 The cable terminal can be of solder type or solderless crimped type. In either case, the instructions laid down for the termination of cables have to be strictly followed. For aluminium cables, aluminium lugs shall be used and for copper cables, copper lugs shall be used.

The equipment should be adequately earthed at two points. Normally the equipment will have two distinct earthing points provided for this purpose.

4.2.6 While terminating aluminium cables, sufficient care has to be taken to remove the oxide layer on the individual aluminium conductor strands. Otherwise, a high resistance joint will be included in the circuit leading to undue heating of the equipment and gradual deterioration of the cable and equipment installation.

4.2.7 If the equipment is of 'off-load' nature, adequate caution notices should be affixed to ensure that the 'off-load' equipment is not operated while the circuit is carrying current. In such an event, isolation shall be made before 'off-load' equipment is operated.

4.2.8 Where equipment are fitted with figure type interlocks, care shall be taken to see that these function correctly.

4.3 Circuit Breakers — under consideration.

4.4 Motor Starters

4.4.1 *Installation Work*

4.4.1.1 Before installation of the starter, it should be ensured that the equipment has been supplied appropriate for the job it is expected to do.

4.4.1.2 It should be ensured that every equipment has its nameplate intact and located in such a way that it may be read easily.

4.4.1.3 When a starter is installed near the motor, care should be taken that it is accessible for maintenance and at the same time, it is important that it does not, in any way, hamper the accessibility to the machines it controls.

4.4.1.4 Correct positioning of controls is essential to ensure safe and effective operation of the driven machine and to make the job of the operator easy. Emergency controls, where provided, shall be in a prominent position, readily accessible and distinctly marked. It is good practice to check the starter, inter-locking devices, limit switches, remote stopping arrangement, etc, for proper functioning before the motor is commissioned. Special care should be taken in case of limit switches to check that the angle and speed of the actuating part is as specified by the manufacturer.

4.4.1.5 While installing equipment, care should be taken that heat generating equipment like resistances are not in the vicinity of other equipment, thereby affecting their rating and operation. This precaution is particularly important for thermal overload protective devices and fuses.

4.4.1.6 In oil-filled starters, resistors, etc, care should be taken that oil of the correct grade is filled up to the marked level. Overload relay should be set in accordance with the recommendations of the manufacturer according to the actual load on the motor.

4.4.1.7 When oil dash-pot type time-lay arrangements are used in the starters, oil of proper viscosity, as recommended by the manufacturer, should be used.

4.4.2 *Connection*

4.4.2.1 The internal connections of the starter should be checked with the wiring diagram supplied by the manufacturer.

4.4.2.2 The external connections should be made to the proper terminals as marked in the wiring diagram. Extra care is necessary for the termination of aluminium conductored cables, for example, by using spring washers, resilient element, grease to prevent entry of moisture, etc (*see* IS : 732-1963*). All connections should be properly tightened. Sometimes, when connections are made, small pieces of insulation and wires fall

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*Code of practice for electrical wiring installations (system voltage not exceeding 650 volts) (*revised*).

inside the starter. Care should be taken to remove such pieces before commissioning. Care should also be taken that the cables do not brush against the conduit or entry hole edges.

4.4.2.3 One of the main causes of entry of dust into the starter housing is the incorrect entry of cable or conduit. Cable or conduit should be properly brought into the housing taking care that the entry hole is substantially dustproof by using cable glands, packed washers, etc.

4.4.2.4 Connecting aluminium to aluminium, copper or brass satisfactorily requires care, particularly if the joint has to be made and broken from time to time, and the use of proprietary compounds recommended for use with aluminium copper or brass connections may be advantageous.

4.4.2.5 Connections should be checked for proper phase sequence. If for star-delta starters, the direction of rotation of the motor has to be reversed, the leads should be changed on the incoming side. In connecting a star-delta starter to the stator winding, it is necessary that the correct order of the six leads from the 3 separate stator windings should be followed to avoid reversing one of the windings.

4.4.2.6 The protective devices should be properly set and checked for their operation. It should be ensured that the fuses are of appropriate type and rating. In some star-delta starters, the overload relay elements are connected in the phase circuits. In such cases the overload relays should be set at $1/\sqrt{3}$ times the line current.

4.4.3 *Testing and Commissioning*

4.4.3.1 *General* — The starter, when installed, should be thoroughly cleaned and checked to ensure that:

a) all electrical connections and nuts and bolts are tight;
b) all components containing oil, other liquid or compound are filled to the correct level;
c) all moving parts, where required, are lubricated;
d) all wiring is in accordance with the wiring diagram;
e) earth connections are properly made; and
f) no tools or loose materials are left in and around the starter.

SECTION 3 SPECIFIC GUIDELINES FOR HIGH VOLTAGE EQUIPMENT

5. SPECIFIC GUIDELINES FOR INSTALLATION OF EQUIPMENT FOR VOLTAGES ABOVE 1 000 V

5.0 Specific guidelines for installation of HV equipment for inclusion in this standard are under consideration. In the absence of the same, the provisions of Section 1 as relevant, shall apply.

APPENDIX A

(*Clause* 3.5.1)

TEST VOLTAGE VALUES FOR INITIAL TEST AT SITE

A-1. TEST VOLTAGE

A-1.1 The values of test voltage for this test shall be in accordance with relevant Indian Standards and shall have approximately a sine-wave form and a frequency between 40 and 60 Hz.

NOTE 1 — The above test voltage may be reduced and the duration of test prolonged in accordance with the following table:

Duration (*Minutes*)	*Test Volts* (*Percent*)
1	100
2	83·5
3	75
4	70
5	66·6
10	60
15	57·7

NOTE 2 — Guidance shall also be taken from the relevant product specifications regarding the value of the test voltage and the duration of application.

A-2. EXTENSION TO EXISTING SWITCHGEAR

A-2.1 The test values specified in **A-1** are subject to modification in the case of switchgear extensions to existing equipment as follows.

A-2.1.1 *Inorganic Insulation* — No ageing occurs and full value of test voltage should be applied.

A-2.1.2 *Organic or Mixed Organic and Inorganic Insulation* — Ageing occurs and a reduced voltage test should be applied.

A-2.1.3 *Equipment Connected to a Normal Source of Supply* — In the case of bus-sections or paralleling breakers and duplicate bus-bar equipment fitted with selectors, the circuit under test and the supply circuit may be brought into the same chamber. In such cases, it may happen that the test voltage and supply voltage are 180° out phase and the test voltage should, therefore, be reduced and the duration of the test increased to compensate for the reduction in phase to earth stress.

A-3. DC VOLTAGE TESTING

A-3.1 There are occasions where dc voltage testing is resorted to particularly when switchgear is tested in connection with cables. In such cases, the voltage to be applied will be 2 × rms value of the ac test voltage. The testing shall be carried out using a calibrated sphere gap as a protection against overvoltage due to distorted waveform.

(*Continued from page* 2)

Panel for Selection, Installation and Maintenance of Switchgear and Controlgear ETDC 20/P25

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Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 411005	5 24 35

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*Sales Office Calcutta is at 5 Chowringhee Approach, P. O. Princep Street, CALCUTTA	27 68 00
† Sales Office is at Novelty Chambers, Grant Road, BOMBAY	89 65 28
‡ Sales Office is at Unity Building, Narasimharaja Square, BANGALORE	22 39 71

Reprography Unit, BIS, New Delhi, India